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Invited Lecture

Thin films for energy conversion and storage devices: status and perspective

Abstract: The rapid consumption of fossil fuels led to a fast development that can be sustained only by creating environmentally friendly energy sources of higher efficiency. Solar cells, fuel cells, batteries and thermoelectric generators are among the most investigated energy devices. Being built in a multilayer layer structure these devices are requiring complex and performant materials with precisely tuned interfaces. The high demand on functionality for bulk, surface or nanostructured materials resulted in a very large number of synthesis methods where the dry processing based on plasma plays a very important role. This work presents examples where thin films produced by plasma assisted processes can help to improve the device properties of solid oxide fuel cells, all-solid-state batteries and transparent conductive oxides for solar cells.

The requirements for a good electrolyte used in all-solid-state batteries include high ionic conductivity, low electronic conductivity, homogeneous morphology, electrochemical stability and good adhesion with the electrode materials. Lithium phosphorous oxynitride (Lipon) is one of the most promising materials but its ionic conductivity needs to be improved. So far, optimal deposition parameters have been obtained but the conduction mechanism allowing further improvements is not known. Our results show that nitrogen dissociation and proper ion energy at the substrate are key parameters to obtain high quality films of Lipon [1].

Recently, perovskite type oxides such as $Sr_{0.94}Ti_{0.9}Nb_{0.1}O_3$ (STN) have been extensively studied for low-temperature solid oxide fuel cells. When pure STN is used as anode, the electrochemical reactions are confined to the electrode/electrolyte interfaces forming a three phase boundary of which length plays a crucial role in improving the anode performance. Our results show that the boundary can be significantly improved by incorporating Pd nanoparticles through a metal functional layer of about 20 nm [2].

Transparent conductive oxides are essential in many optoelectronic applications including solar cells. Thin doped indium oxide is intensively used. However, due to limited abundance it needs to be replaced and one of the main candidates is doped ZnO. Magnetron plasma sputtering can be a cost effective method for depositing Al doped ZnO but the film uniformity is spoiled by the energetic negative ions of oxygen released mainly at the erosion tracks. In this context, our effort is concentrated in understanding the role of negative ions during the film growth.

[1] Ane S. Christiansen, E. Stamate, K. Thyden, R. Younesi, P. Holtappels, J. Power Sources, 273 (2015) 863.

[2] A.M. Hussain, J.V.T. Hogh, W. Zhang, E. Stamate, K.T.S. Thyden, N. Bonanos, J. Power Sources, 212 (2012) 247.

Biography:

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Field: Plasma Processing, Thin films

Research interest: Batteries, Transparent conductive oxides, Fuel cells.

- Oxynitrides, Perovskites, ZnO
- Nanoparticles, plasma deNOx

Educational Background:

Doctor of Engineering, Nagoya Institute of Technology, Nagoya, Japan (2001)

PhD in Physics, Al. I. Cuza University, Iasi, Romania (1998)

Professional Experiences:

Senior Scientist, Technical University of Denmark, Denmark (2006 – present)

COE Associate Professor, Nagoya University, Japan (2003-2006)

JSPS fellow, Nagoya University, Japan (2001-2003)

VBL Lecturer, Nagoya Institute of Technology, Japan (1999-2001)

PhD student (Monbusho), Nagoya Institute of Technology, Japan (1996-1999).

Research Assistant, Al. I. Cuza University, Romania (1991-1996)

Awards:

"Plasma Physics Innovation Prize 2012" awarded by the European Physical Society

Selected Publications:

A. Christiansen, E. Stamate, K. Thyden, R. Younesi, P. Holtappels, Plasma properties during sputtering of lithium phosphorous oxynitride thin films, J. Power Sources 273 (2015) 863.

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